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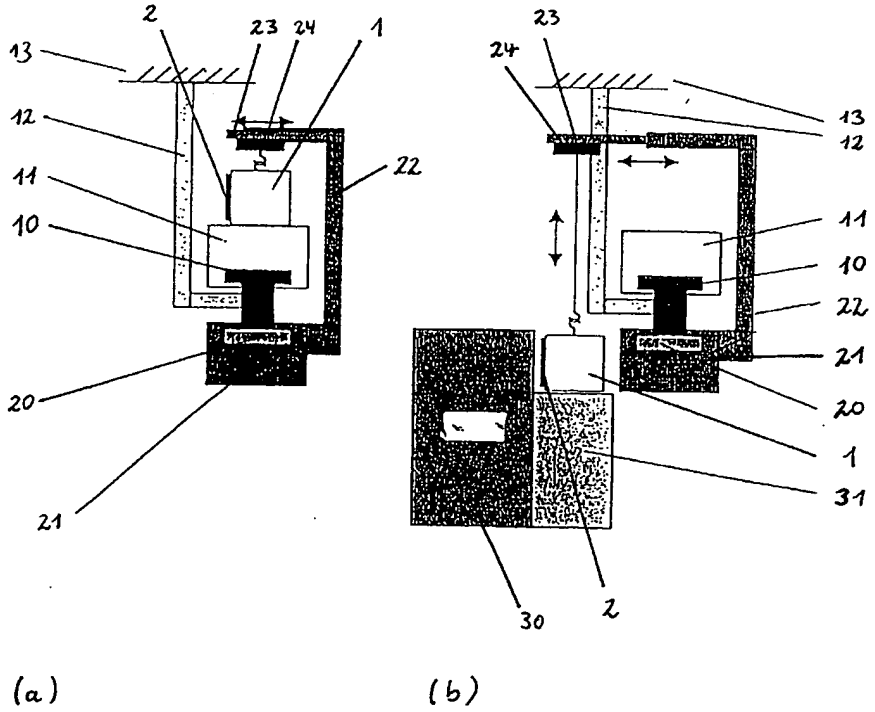
(54) Arrangement for transporting a semiconductor wafer carrier

(57) For bay type structures of semiconductor wafer transport systems an arrangement is provided with interbay rail tracks (10) and intrabay rail tracks (20) mounted on each other, and the vehicles (11) of the interbay system, and the carrier transfer cars (21) of the intrabay system can move freely bidirectional inside the bay area without obstructing each other. The carrier transfer car is designed such that a wafer carrier (1) can be directly loaded from the vehicle (11) to the load port (31) of a processing machine.

The arrangement simplifies and accelerates the transfer, and enhances the flexibility of vehicles in wafer transport.

Fig. 1



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Description

[0001] The present invention relates to an arrangement for transporting a semiconductor wafer carrier.

[0002] In semiconductor device manufacturing systems, in particular in wafer fabrication, automatic transport systems increasingly accomplish the transfers of device carriers (such as wafer cassettes, also called carriers), which contain a number of devices, e.g. wafers, inbetween subsequent fabrication process steps. A commonly used structure is the organisation of manufacturing systems into bay type areas inside a cleanroom. Processing machines of the same kind are condensed into bays in order to combine machine specific chemical and electrical supply, and to give operators short distances to attend the machines, and in particular to simplify transport systems, since lots processed on different machines of the same kind remain spatially together.

[0003] Usually, transport systems comprise interbay systems, which connect all the bay areas throughout the fabrication system, and intrabay systems which comprise an annular rail track inside the bay area, with the functionality of receiving wafer carriers from interbay vehicles via stocker equipment, and of transferring the wafer using carrier transfer cars to a free load port of any unused processing machine and vice versa. The stocker equipment serves for transposing the wafer carriers between the different systems, whereby on-top-vehicles are often used for the interbay rail tracks. The carrier transfer cars move to the processing machines, where individual wafer handlers load the load ports of the processing machines or operators perform this task manually.

[0004] With decreasing cycle times of the processing machines and increasing cleanroom specifications the non-value-added costs due to travel time and the footprint of transport equipment in the cleanroom area become important for wafer fabrication costs. In case of the manufacturing systems being heavily loaded long waiting times can arise at the stocker equipment or at the load port of the processing machines. Vehicles involved in transposing their carrier load may obstruct other vehicles, which are to pass the aforementioned bottleneck, i.e. stocker equipment or the load port. Moreover, stocker equipment requires expensive footprint in the cleanroom area and has to offer high availability, resulting in increased costs for service.

[0005] In WO 98/58402 there is disclosed an apparatus for automated cassette handling, wherein the apparatus provides the functionality of receiving cassettes or carriers from a conveyor. The conveyor extends though an inner portion of an elevator chamber of the apparatus, from where it can be lifted by an elevator onto a position, where a wafer handler can load the processing chamber of the attached processing machine. The apparatus enables a passage of a following second wafer carrier without obstruction by the first wafer carrier in process, thus avoiding the build-up of queues in front of the apparatus. Nevertheless, the transport system is restricted to conveyor lines, and thus lacks the flexibility of dynamically loading different machines with disposable transfer mechanisms as in the case of carrier transfer cars of the common intrabay system.

[0006] It is a primary object of this invention to provide an arrangement for transporting a semiconductor wafer carrier in wafer fabrication processes, which reduces the amount of travel and load or unload times between subsequent processing steps, and where less transport equipment is necessary to transport semiconductor wafers to the processing machines.

[0007] The objective is solved by an arrangement for transporting a semiconductor wafer carrier, which comprises an interbay transport arrangement comprising an interbay rail track with vehicles moving on the tracks, for connecting a plurality of bays, said vehicle for transferring the wafer carrier between different bays according to their processing sequence, an intrabay transport arrangement comprising an intrabay rail track with a carrier transfer car being freely disposable along the track within the bay area, for transferring the wafer carrier between said interbay transport arrangement and the processing machines, said interbay rail track reaching into the bay area, thereby passing each of the processing machines, and said intrabay rail track, which is mounted along the interbay rail track within the bay area, said carrier transfer car having a hoist arm with a means for lifting up or down the carrier and for depositing the wafer carrier on the load port of one of the processing machines, whereby the hoist arm is designed to leave a free carrier load space between the vehicle and the hoist arm, for enabling the vehicle carrying the wafer carrier and the carrier transfer car to pass each other without mutual obstruction on their tracks.

[0008] According to the present invention, an arrangement is provided, that significantly reduces the time needed to transfer a semiconductor wafer carrier from a first to a second processing machine within an intrabay. The interbay rail tracks are led into and completely through the bay area in order to enable the vehicles of the interbay transport arrangement to bring their carrier load directly in front of the processing machine, that is due to perform the next process step in the wafer fabrication sequence.

[0009] At this location the vehicle can meet a carrier transfer car of the intrabay transport arrangement, which performs the task to receive the wafer carrier and to direct the load to the load port of the processing machine. Thereby, the stocker step, i.e. the transfer of the wafer carrier between interbay and intrabay arangement, and the loading step of the processing machine can be carried out in just one movement, thus saving time and reducing the amount of bottleneck locations.

[0010] Further improvement in throughput arises from the improved functionality, that two or more vehicles can enter the bay area within a comparatively small time dif-

ference such that many processing machines can be loaded in parallel, depending on the number of vehicles used. Besides the transfer velocity improvement, saving of costs can be additionally gained, because most of the transport throughput inside the bay area can be achieved by the use of cheaper interbay vehicles, whereas less numerous but expensive carrier transfer cars can be required due to their dynamical flexibility.

[0011] The vehicle and the carrier transfer car can meet anywhere in the bay area, since both tracks are mounted on each other and the carrier transfer car can move to any place along the intrabay rail track. Even in the case of all load ports in the present bay being occupied, the vehicle can deliver its carrier load to a carrier transfer car at a non-load-position and then being free to receive another transfer task, while just the carrier transfer car waits for a free load port. Thus, free vehicle capacity for the interbay arrangement is retained.

[0012] The hoist arm mounted on the carrier transfer car supplies the versatility of performing the load and transfer tasks without obstructing neither the interbay rail track construction nor the vehicle, which can pass through the carrier transfer car position. For the reason that both the vehicle with load and the carrier transfer car cannot obstruct each other, there is extensive room for a planning and optimisation procedure, depending on how many vehicles, carrier transfer cars and free load ports are available in the bay area, thus keeping a desired balance between occupied vehicles and carrier transfer cars. E.g., if vehicles are urgently needed in other areas, they quickly release their carrier load to carrier transfer cars at a non-load-position in the bay entrance area and resume their path to a new operational area.

[0013] The kind of attachment of the intrabay rail track to the interbay rail track may be chosen, such that the intrabay rail track is mounted separately from the interbay rail track on the cleanroom hall structure, preferably on the ceiling. This construction offers the possibility of a partly independent an intrabay rail track guidance. E. g., carrier transfer car service areas or parking positions can be provided.

[0014] The intrabay rail tracks can as well be directly mounted on the interbay rail track, which reduces the amount of expensive and obstructing support constructions. Relative spaces between both track systems are then guaranteed to be constant along the mounted track.

[0015] A further aspect considers an extendable hoist arm for the carrier transfer car, which achieves a fast removal of the wafer carrier from the wafer carrier load space above the vehicle. The hoist arm can be extended into a position, where the wafer carrier cannot obstruct with other wafer carriers being deposited on top of another vehicle that passes through the present location of the carrier transfer car. This feature further improves the flexibility of the intrabay transport arrangement.

[0016] In a further aspect the extension means of the hoist arm is constructed such as to reach a position above the load port of the processing machine, from where the wafer carrier can be directly lifted down to the load port, thus rendering special load port equipment superfluous.

[0017] Analogously the hoist arm can be designed as a gripper arm that can be extended. It takes the wafer carrier with the gripper, removes the carrier from the load space, and then extends down to the load port with the improvement, that horizontal movements can be achieved. E.g., Special barriers can be circumvented or load ports of processing machines can be reached, which are shifted relative to the rail tracks.

[0018] A further aspect employs a winch and rope as the mechanism to lift and deposit the wafer carrier from the vehicle to the load port and vice versa. This construction offers a simple and cost-saving solution to perform the transfer.

[0019] A further aspect provides the bidirectional driving functionality of both vehicles and cars independently from each other, enabling dispatched vehicles to find the shortest way out of the bay area in order to resume another task, thus increasing the general availability of interbay vehicles.

[0020] A further aspect provides junctions for the bay each employing switches for entering or exiting the bay area with any combination of direction. A portion of the interbay rail track is supplied, that enables the vehicle to skip the current bay area and to continue on an interbay route. Alternatively, the vehicle can enter the bay area via said switches into the second portion of the interbay transport arrangement, which is the bay area portion of the interbay rail track.

[0021] Preferably, an annular interbay and intrabay rail track layout within the bay is provided with two junctions within the ring both connecting the bay area rail tracks with the external interbay transport arrangement. The locations of the two junctions correspond to prior art stocker port positions. Thus, an entrance and an exit junction is implied, but the meaning of both junctions can also be exchanged, since vehicles can move bidirectional on their tracks and switches. This allows for flexible dispatching of vehicles into and out of the bay area.

[0022] In case the vehicle can enter the intrabay area via two junctions inside the annular ring of the bay area, the problem of wafer carrier orientations on the vehicle is solved by two further aspects. The first aspect is that junctions are supplied which switches, which have control means to rotate the wafer carrier on top of the vehicle. If the vehicle passes the switch into the bay area, the orientation of the wafer carrier doors can be detected automatically and can be compared which the information about the position of the processing machines along the track behind the switch inside the bay area. If the orientation of the wafer carrier door is opposite to the load port of one of the processing machines, all wafer carriers on top of the on-top-vehicles can be rotated by 180 degrees. This feature renders manual operator attendance unnecessary when loading the load port of the

processing machine. A mechanical implementation as well as an electronic realisation are feasible.

[0023] The second aspect deals with rotating the whole platform, on which the wafer carriers are deposited on top of the on-top-vehicles, instead of individual wafer carriers, thereby reducing the complexity of the rotating equipment. The wafer carriers are fixed on the platform, all having the same wafer carrier door orientations. If the vehicle enters the bay area via the switch, said automatic detection and rotation process acts on the platform as a whole. The means to rotate the wafer carrier or the platform according to both aspects can be mounted on the vehicle or externally.

[0024] In a further aspect the carrier transfer car can cross the switches of the inter bay rail track system. This feature results in the aspect, that carrier transfer cars can reach remote areas. E.g., intrabay rail tracks can be mounted on interbay rail tracks beyond the switches outside the bay area for enabling the carrier transfer cars to serve processing machines outside of any bay area or in other bays. This gives the advantage, that carrier transfer cars can be concentrated throughout the fabrication system just where they are needed thereby reducing the total number of carrier transfer cars required for the fabrication system.

[0025] In a further aspect the intrabay rail track is mounted directly beneath the interbay rail track with the carrier transfer cars moving on the intrabay rail track in a floating rail type as well beneath the vehicles, which in this aspect are called on-top-vehicles. The carrier transfer cars are provided with hoist arms, which lead around the guide-rail to a position above the on-top-vehicles, the whole arrangement saving efficiently space due to the rare use of support arms, the compact construction of both guide-rails and the hoist arm fitting in with the interbay rail structure. Moreover, the height above ground of the construction reduces footprint of the transport arrangement.

[0026] An embodiment of the invention is now described with reference to the drawings. In the drawings:

Figure 1 (a) and (b) show a side view of a carrier transfer car according to the invention with a hoist arm latching to the connector on top of a wafer carrier (a) and with an extended hoist arm depositing the wafer carrier on the load port of a processing machine (b).

Figure 2 shows a top view of an interbay area with vehicles moving on the interbay rail track and carrier transfer cars moving on the intrabay rail track.

Figure 3 (a) and (b) show a switch according to the invention with a disposable insertion in a straightahead position (a) and in a turn-left position (b).

[0027] A remotely controlled vehicle 11 in Figure 1(a) moves on an T-shaped guide-rail representing the interbay rail track 10, thereby carrying the wafer carrier 1. The T-shaped guide-rail track is mounted on support arms 12, which are themselves mounted on the ceiling 13. The whole system represents an overhead transport system. Beneath the T-shaped guide-rail track 10 another guide-rail is horizontally flanged representing the intrabay rail track 20. A carrier transfer car 21 is moving in a floating rail type beneath this guide-rail track 20 along the interbay rail track 10. A crane-type hoist arm 22 is mounted on the carrier transfer car 21 at the opposite side of the support arms 12, which hold the rail tracks 10 and 20. The top of the hoist arm 22 is provided with a winch and roap structure 24 that latches on to a connector 3 on top of the wafer carrier 1. In the specific situation displayed in Figure 1b, the carrier transfer car 21 and the on-top-vehicle 11 have already met to start the transfer of the wafer carrier. The crane-type hoist arm 22 is mounted off-axis of the rail tracks 10 and 20 and leads around the rail tracks to a top position beneath the ceiling 13 sufficiently high above the vehicle platform in order give passage to a vehicle loaded with a wafer carrier 1.

[0028] Ideally, the transfer happens in front of a processing machine 30 having a load port 31 in front of it, which is shown in Figure 1(b). The hoist arm 22 has an extendable arm 23 on its top which can be extended to reach a position above the load port 31 using the winch and rope 24. the wafer carrier can be lifted down onto the load port 31 with the wafer carrier door 2 orientated into a loading position for the process chamber of the processing machine 30. After this moment displayed in the figure the vehicle 11 can already resume its path to search for another task. Additionally, other vehicles can pass through the current position where the carrier transfer car 21 is still busy with depositing the wafer carrier 1.

[0029] The two situations given in Figure 1 are shown for the same preferred embodiment in a top view in Figure 2. Several vehicles 11a - 11c are moving along the interbay rail track 10 inside the bay area to reach their destined load ports 31. The vehicles 11b and 11c are already in load position and represent the situations shown in Figure 1(a) for vehicle 11d, and Figure 1(b) for vehicle 11c, where carrier transfer cars 21b and 21c serve the transfer. Vehicle 11a already found its destined position at a load port 31 in front of a processing machine 30, and the carrier transfer car 21a is about to reach the location. Vehicle 11d and carrier transfer car 21d seem to be as well about to meet a free load port 31. Because this embodiment according to this invention gives room for a planning and optimisation scheme, time can be saved and resources can be enhanced, if carrier transfer car 21d skips and passes through vehicle 11d and meets with vehicle 11e, which is just entering the bay area at another load port being the destined position of vehicle 11e. This can arise due to the possibility, that carrier transfer car 21c is just about the finish serving the transfer between vehicle 11c and its load port

31. Then, carrier transfer car 21c will move to the neighbouring position of vehicle 11d serving that transfer, while vehicle 11c is starting to leave the bay area by moving counterclockwise through the bay. When it reaches the position of vehicle 11b, the latter vehicle will be released from the carrier transfer car 21b having lifted the wafer carrier 1, and both vehicles can transit to the bay exit junction 40. In the mean time, vehicle 11a and carrier transfer car 21a will have conducted the transfer and all three vehicles 11a, 11b and 11c can pass through junction 40.

[0030] An advantage of this embodiment according to the present invention is, that there exist two junctions 40 and 41, which connect the intrabay system containing the interbay rail tracks 10 and the intrabay rail tracks 20, and the interbay system consisting of the interbay rail track 10. With the functionality of all cars and vehicles moving bi-directional queuing can be avoided by using the optimum path in and out of the bay area.

[0031] The wafer carrier transfer according to this embodiment can still be accelerated by attaching electrical or mechanical means to switches 42 of the junctions 40 and 41 and the vehicles 11, which automatically rotate the wafer carriers 1 on top of the vehicle 11e in order to align the wafer carrier door 2 with the load ports 31. Each means of the switches and the vehicles comprises a tool, with which it can deduct the orientation of the wafer carrier 1 of the current vehicle 11e. The means compares this detected orientation with locally stored information about whether the load ports 31 along the rail track 10 and 20 beyond the switch 42 are attached left or right to the rail track. The tool then has the feasibility to decide whether to rotate the wafer carrier 1 or not. According to this embodiment this will be accomplished by a computer network based manufacturing execution system.

[0032] This embodiment deals with switches 42 that comprise insertions, that can be disposed perpendicular to the interbay rail track shown in Figure 3. In the position of switch 42 shown in Figure 3(a) the vehicle 11(f) of Figure 2 moves straight ahead and skips the bay area. Accordingly, vehicle 11(f) will turn left when the position of switch 42 is such as represented in Figure 3(b).

Claims

1. Arrangement for transporting a semiconductor wafer carrier, comprising

   - an interbay transport arrangement, which comprises an interbay rail track (10) and a vehicle (11) moving on the track, for connecting a plurality of bays each comprising processing machines (30),
   - said vehicle (11) for transferring the wafer carrier (1) between different bays according to their processing sequence,
   - an intrabay transport arrangement, which comprises an intrabay rail track (20) and a carrier transfer car (21) moving on the track within a bay area, for transferring the wafer carrier (1) between said interbay transport arrangement and the processing machines (30),
   - said carrier transfer car (21) being freely disposable along the intrabay rail track (20),
   - said interbay rail track (10) reaching into the bay area, thereby passing each of the processing machines (30),
   - said intrabay rail track (20) being mounted along the interbay rail track (19) within the bay area,
   - said carrier transfer car having a hoist arm (22) with a means (24) for lifting up or down the wafer carrier (1) and for depositing the wafer carrier (1) on a load port (31) of one of said processing machines (30), whereby the hoist arm (22) is designed to leave a free carrier load space between the vehicle (11) and the hoist arm (22), for enabling the vehicle (11) transferring the wafer carrier (1) and the carrier transfer car (21) to pass each other without mutual obstruction on their tracks.

2. The arrangement for transporting a semiconductor wafer carrier according to claim 1, **characterised in that** the hoist arm (22) is extendable for moving the lifted wafer carrier (1) out of the carrier load space above the vehicle (11) into a position, where the vehicle carrying a second wafer carrier can freely pass the carrier transfer car (21).

3. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 or 2, **characterised in that** the extendable hoist arm (22) is designed to lift the wafer carrier (1) down to the load port (31) of the processing machine (30).

4. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 3, **characterised in that** the hoist arm (22) comprises a winch and a rope (24) for lifting the wafer carrier (1).

5. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 4, **characterised in that** both the vehicles (11) and the carrier transfer cars (21) each can independently move in both directions along their rail tracks without obstructing each other.

6. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 5, **characterised in that** the interbay rail track (10) comprises a first portion, which connects the plurality of bays, and a second portion, which reaches into

the bay area, both portions being connected by a junction (40), said junction (40) having switches (42) to enable a vehicle (11) on the first portion to branch off into the second portion when travelling in either direction, and to enable a vehicle (11) of the second portion to enter the first portion in either direction.

7. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 6, **characterised in that** said vehicle (11) has a means to rotate the wafer carrier (1) and that the junction (40) has a control means to rotate the wafer carrier (1) when the vehicle (11) passes over the switch (42).

8. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 6, **characterised in that** said vehicle (11) comprises a rotatable platform with the wafer carrier (1) being fixed on the platform, and that the junction (40) has a control means to rotate the platform with the wafer carrier (1) when the vehicle (11) passes over the switch (42).

9. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 8, **characterised in that** the intrabay rail tracks (20) are mounted along the interbay rail tracks (10) beyond the bay area for allowing the carrier transfer cars (21) to load or unload single processing machines (30), which are positioned in other bays or outside of any bay, and for exchanging carrier transfer cars (21) with other bay areas, and that said switches (42) have means to turn the hoist arms (22) down upon entering or exiting the bay area.

10. The arrangement for transporting a semiconductor wafer carrier according to anyone of claims 1 to 9, **characterised in that** the intrabay rail track (20) is mounted beneath the interbay rail track (10), and that the vehicle (11) moves on top of the interbay rail track (10), and that the carrier transfer car (21) moves below the vehicle (11) with said carrier transfer car (21) having a hoist arm extending above the vehicle (11).

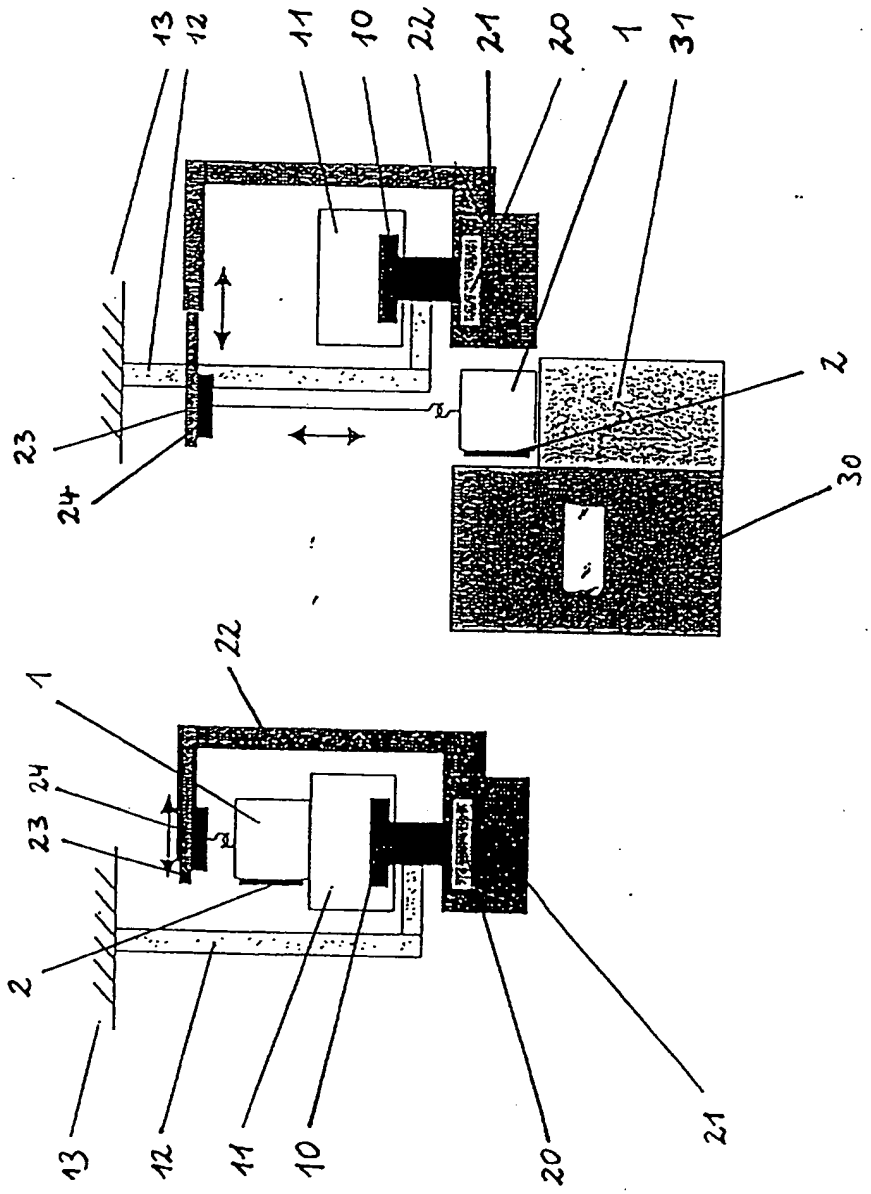
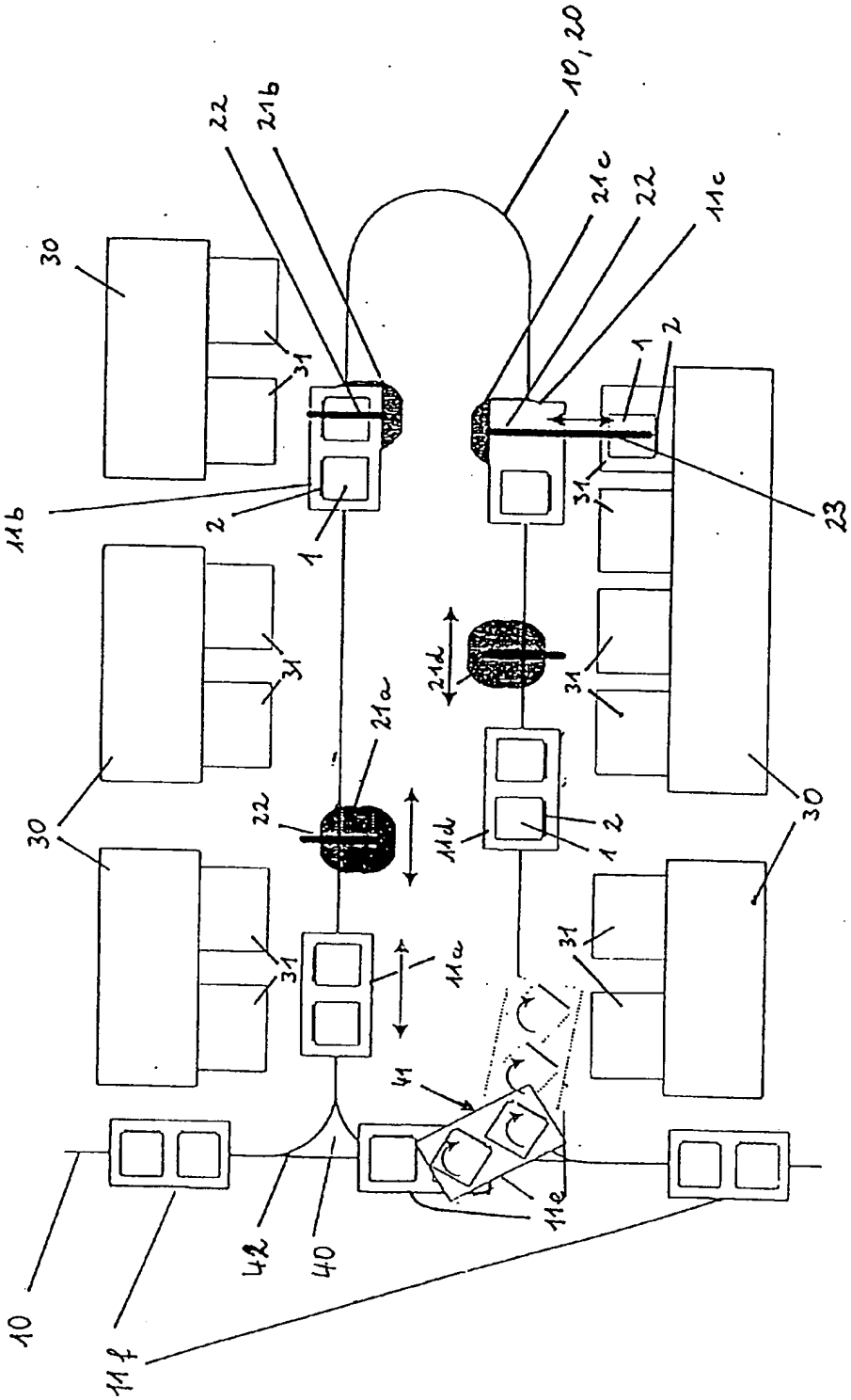


Fig. 1


10, 20
22
21b
21c
22
11c
30
31
1
2
11b
23
21d
21a
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41
11a
11e
42
40
10
11f

Fig. 2

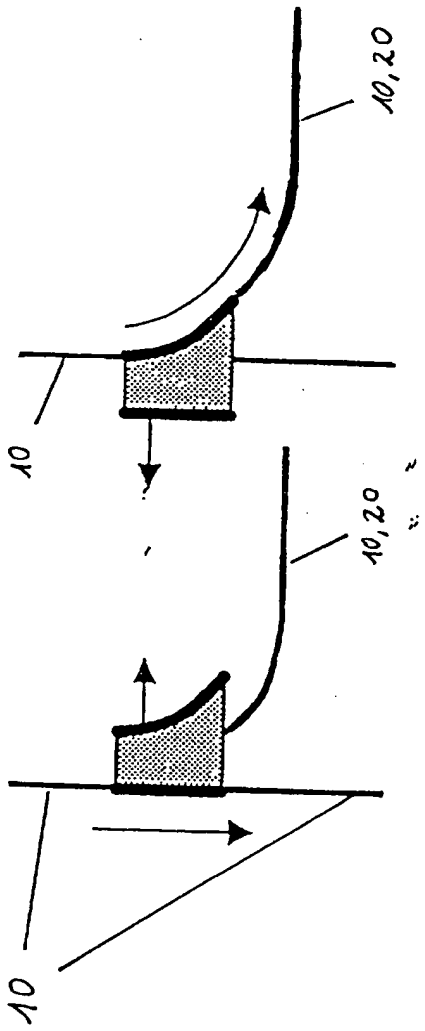

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 12 3165

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 00 37338 A (ASYST TECHNOLOGIES) 29 June 2000 (2000-06-29) * abstract; claims; figures * * page 4, line 10 - page 5, line 25 * * page 9, line 25 - page 14, line 18 *	1-9	H01L21/00
A	---	10	
X	US 5 980 183 A (FOSNIGHT WILLIAM J) 9 November 1999 (1999-11-09) * abstract; figures 5-13 * * column 4, line 25 - column 5, line 55 * * column 6, line 19 - column 14, line 12 *	1-9	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	6 March 2001	Hamdani, F

CATEGORY OF CITED DOCUMENTS

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06-03-2001

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